Waste as Opportunity - A MAHB Dialogue with Materials Scientist Veena Sahajwalla

Image courtesy of Geoff Holland

Geoff Holland: What is a circular economy, and why is it important?

Veena Sahajwalla: This is really about keeping in circulation, for as long as possible, the materials from our goods and products. It is not just about singular circulatory of materials and processes, but intersecting circulatory where one person's waste is another's resource or feedstock and where there are often multiple new uses of that person's waste.

So a circular economy is really about respecting and valuing the materials that we use in our everyday lives. It's thinking about how we can completely eliminate what we refer to as waste that ends up in landfill. We look at used materials and products, and when these products have reached the end of their lives, to actually bring those materials back into our economy and bring them back into production. This concept is at the heart of what we do in our microrecycling science and with our Microfactorie® technologies at the Sustainable Materials Research and Technology Centre (SMaRT) at the University of New South Wales in Sydney, Australia, which is basically treating waste as a renewable resource.

The idea of a circular economy is to reuse, repair, and recycle, but at the SMaRT Centre we also 'reform' waste into value-added products and materials for remanufacturing to keep the waste out of landfill. In a true circular economy, we're not really calling anything waste. Rather, we are reforming our waste so that we can actually reuse those materials over and over again, through remanufacturing.

GH: You have said that waste is not a problem to be managed, it is an opportunity to be explored. Can you elaborate?

VS: People see waste as a problem because a lot of materials are locked into products deemed too hard to recycle.

Take for example all of the different types of plastics we all use, from soft plastics to hard plastics in printers. These are currently not subject to mainstream recycling but there is value in these materials that have not yet been unlocked. The opportunities to realize the value of these materials – which are not appreciated or understood – is something we at the UNSW SMaRT Center have been researching and developing technology for over a decade. Our societies actually have to start to really address our waste challenges. We need to stop using landfill and incinerators and stop turning a blind eye to the lost value of treating our waste in these ways.

Since COVID-19 has disrupted global supply chains, manufacturing has come under sharp focus. The problem of countries now being affected by unreliable global supply chains for certain materials and goods has sparked questions around how to produce the goods they need.

Ever-increasing population, technological advancement, variable consumption trends, and lack of efficiency in using materials are forcing us near a crisis point in terms of waste management, so we need greater coordination between the researchers/scientists and industry and government to deliver more innovative outcomes, particularly for the small and mediums sized enterprises, the SME sector.

Perhaps the greatest opportunity to innovate more is in the SME sector. SMEs often fall between the cracks in R&D funding from governments, but they are usually agile and innovative. So, this is where we can get the greatest growth and innovation needed for our manufacturing sector, where manufacturers are also recyclers). To me, I see research organizations like the UNSW SMaRT Centre as helping to create new business to business supply chains, growth opportunities, and jobs, let alone the environmental benefits, and we are actually doing that with small, medium, and large businesses right here in Australia.

GH: You developed a process called 'Polymer Injection Technology' or Green Steel. How is that changing the manufacturing of steel, and can this kind of solution be applied to other industries?

VS: Our Green Steel innovation is a technology we developed to help make green alloys, using end-of-life rubber tires and waste plastics as an alternative to coke and coal in steel making. Officially known as Polymer Injection Technology, Green Steel is licensed to key UNSW SMaRT Centre industry partner, MolyCop, for use in its electric arc furnaces in Australia and globally.

SMaRT Centre research in this area is ongoing and further innovations using waste materials for steel making, and for aluminum, are in development as part of our 'green manufacturing' work.

I'm pleased to say our Green Steel technology is already paving the way for green manufacturing, using the elements of hydrogen and carbon from old rubber tires and plastics as an alternative for coal and coke. Recycling in new ways like this using new technologies can be a foundation for the manufacturing of high-quality materials from our waste resources, as we seek to develop greater sovereign capability and improved economic prosperity.

Innovatively recycling and reforming waste materials for completely new uses – for example obtaining hydrogen from waste materials as an energy source and input material for manufacturing like steelmaking – should be at the center of how we transform our industrial sectors. This is the heart of what we call the concept of green manufacturing, and we have developed other technologies and products based on this concept.

GH: You talk about green manufacturing. What is green manufacturing, and why is it important in this era of climate change and resource limits?

VS: For me, I see a new era in the alignment of recycling and manufacturing, and so you could call that green manufacturing. It is where manufacturing input materials come (where possible) from recycled content via another business.

It's about creating new economies that value materials, but not economies of scale, but economies of purpose. Scale implies it must be big to survive but that is simply not the case. Scalability is not just making something bigger, but expanding capability in a distributed or decentralized way, with enough built-in flexibility to ensure local needs are catered to. I'm challenging this traditional scalability notion because it can come from replication. Innovation can be scaled in this way. Our goal is to replicate our technology in a customizable way.

Doing onshore and more sophisticated processing of recycling as part of manufacturing can change the game for Australia, and all countries around the world, particularly given the current waste, recycling, and manufacturing challenges. The goal is to eliminate the word waste from our vernacular because waste should become the renewable resource we know it is. This will only occur when the value inherent waste has been harnessed. The next challenges are taking on the difficult materials currently not being recirculated back into the economy, such as complex and or contaminated plastics and critical materials from e-waste and batteries, for instance. Using green manufacturing where we extract the valuable materials from waste and keep them in circulation is the future I can see.

GH: What are waste Microfactories, and how are they changing the way e-waste and other industrial waste materials are managed?

VS: We at the UNSW SMaRT Centre pioneered Microfactories® technologies to reform different waste streams that mostly end up in landfills or stockpiles by turning them into value-added 'green materials and products. Microfactorie® technologies use various discreet modules to transform problematic waste materials, such as glass, textiles, and plastics, into new value-added materials and products.

We have a Microfactorie® module that produces engineered green ceramics for the built environment made from waste glass and textiles. It can also produce a range of flat panels for buildings made from wood, plastic, and other waste such as organic materials like coffee waste.

We have another module that produces filament for 3D printing made from waste plastic. This modular technology is capable of harnessing value from our waste resources to deliver high-value materials and products. The SMaRT Centre now houses various Microfactories® and is collaborating with industry partners to test and operate these modules in industrial settings.

GH: Several European nations are using a combination of recycling and incineration to dramatically reduce the percentage of solid waste that goes to landfill. In Sweden, it is down to less than one percent of the total volume. Do you see a day when no waste will be left to landfill, and current landfills will be mined to recover useful waste?

VS: I do see a day where technology will help us overcome the need for landfill and incinerators.

With respect to waste to energy incineration, despite an initial appetite for this sort of technology - mainly by industry, obviously, and in Europe where land is scarce - there is a growing concern across various jurisdictions including Australian states, particularly NSW, that this is perhaps not the best use of resources to help manage waste. Yes, it is still seen as a policy option in many places, but there are concerns from researchers and policy folk that burning waste materials destroys those materials forever, never to be recovered. And, in relation to the ROI, often not all costs are considered across the dimensions of social, environmental, and economic impacts. We have shown that supposedly hard or impossible to recycle plastic can become a value-added material, as filament for 3D printing, for instance. So the missed opportunity cost of burning this plastic means you would miss out on the ripple benefit effects of making that filament.

GH: How can we look to nature for inspiration as we rethink the Earth system and the process that processes that shape our lives?

VS: I know a lot of people may not see the repair economy as part of manufacturing, but I think we have to if we're truly going to embrace sustainability and increasing the life of products. So we have to have a 'repair strategy'. The ability to do that comes back to understanding the functionality of different types of products.

The analogy with the human body comes to mind. Think of it this way: when you have, for example, a broken bone, or you want to be able to replace a hip, or you want to be able to repair your skin because you might have had an accident, medical professionals have amazing medical science to repair those parts of the body. Think about the resilience human beings have to be able to repair our bones and our surfaces and indeed replace so many different parts of our body. This is how nature has made humans to be resilient. The whole repair notion has improved the quality of lives, but that has happened only because medical professionals have found ways to use different materials to repair and enhance human physical health. If we can do that on humans, I'd like to think we can design, build and

manage our machines in the future with the use of far more repairing, rather than throwing them away which is how we mostly treat devices that often only need a new part. That way we can increase efficiencies and improve the outcomes of our machines and devices, thereby prolonging their life and delivering greater sustainability. I think we have to learn from nature more and from the world of material and medical sciences.

One of the new UNSW SMaRT Center technologies we've developed is called materials microsurgery. We've shown that we can repair various components, by using the valuable elements from waste materials to improve the surface of steel, for instance. So we have shown you can use nanoceramics as coatings on the surfaces of metals to improve their properties. We can improve the performance of that metal by creating these beautiful new surfaces that are made out of ceramics, enhancing its life by increasing its wear resistance.

We've shown that we can do so much better when we start to think in a much more holistic way. Mother Nature can inspire us to think about our technosphere in that way. Let's imagine a future where all kinds of Microfactories are repairing parts and components, making us so much more sustainable and resilient as a society. Let's be inspired by nature to find solutions that can make life easier and more affordable for everyone on this planet.

GH: The world's oceans are teeming with billions of tons of human plastic waste. Are there answers that can eliminate this waste and restore the vitality of our marine ecosystems?

VS: Yes. We need to bring this waste onshore and to process it. But first, we also need to prevent it from getting into our oceans and waterways. To do that, I think we need stronger 'product stewardship', where producers of products and users of products are more accountable for when they come to their so-called end of life. This means better collection and recycling, using new technologies to extract and reform the valuable elements they contain, as I have been saying.

We also need better behavioral responses. We have awareness campaigns for many things but better waste and recycling management is needed for industry and consumers. There are some amazing things already underway, but the scale of some of our waste challenges means we need to do much more to tackle these issues. And I do see a role for our modular Microfactorie® technology being used in regional and local sites to not only prevent waste from being stockpiled and discarded but used for remanufacturing. That way the waste becomes valuable and isn't seen as something to be discarded.

GH: What can each of us do as individuals to encourage a future that is life-affirming and sustainable?

VS: Ask what choices you have.

For instance, we have some small industry partners who are doing this and are becoming more sustainable, using waste as a resource, and their customers and stakeholders see this as helping to chart a new sustainable course for the earth. For me, it is not about waiting for someone else to do

something we want but doing the things that we can do now for ourselves. This means taking on more responsibility for our actions, such as the things we buy and dispose of, for example. I think most people do want greater sustainability and we need to harness this willingness to make positive changes across all areas of life, from policy setting through to role modeling.

GH: What is your next big challenge?

VS: For me, it is continuing my work. We have achieved so much in recent years but I realize there is just so much more to do. The research takes time. I think researchers need to collaborate with industry, governments, and the community more so the research can be applied in the real world.

I have a lot of projects underway and one really exciting initiative is that we will soon start the new Australian Research Council Microrecycling Hub into batteries and other consumer wastes. Involving many industry partners and other research institutions, we will work over the next five years to progress research and development of new recycling technologies.

Professor Veena Sahajwalla is an internationally recognized materials scientist, engineer, and inventor revolutionizing recycling science. She is renowned for pioneering the high-temperature transformation of waste in the production of a new generation of 'green materials.' In 2018, Veena launched the world's first e-waste micro-factory and in 2019 she launched her plastics micro-factory, a recycling technology breakthrough. She is producing a new generation of green materials and products made entirely, or primarily, from waste. Veena also heads the ARC Industrial Transformation Research Hub for 'green manufacturing', a leading national research center that works in collaboration with industry to ensure new recycling science is translated into real-world environmental and economic benefits. In 2019 she was appointed inaugural Director of the Circular Economy Innovation Network by the NSW Government through its Office of Chief Scientist and Engineer.

The MAHB Blog is a venture of the Millennium Alliance for Humanity and the Biosphere. Questions should be directed to joan@mahbonline.org